A Brief History of HexSim

-- Nathan Schumaker --

I was hired by EPA (at WED) in 1997. At that time, I was working on the Pacific Northwest Ecosystem Consortium (PNW-ERC) project. My contribution to this study involved the development of a wildlife simulation model that I named PATCH. The PNW-ERC ended with the publication of our 2004 special issue in Ecological Applications.

After the PNW-ERC, I began searching for other ways to contribute to EPA, and did not intend to build another large computer simulation model. But as fate would have it, the NHEERL ADS (at the time, Gil Veith) made a connection between my work and a need that was developing within the Environmental Fate and Effects (EFED) division of OPP. Ultimately, I committed to building a model that could quantify the impacts that regulated pesticides are likely having on wildlife species of concern. This need grew out of multiple successful legal actions taken against EPA. In short, EPA was found to be negligent for not addressing the impacts that regulated pesticides were having on species protected under the ESA, the marine mammal protection act, NEPA, etc.

I knew from the outset that the EFED model would be hard to build. The reasons for this included:

- Populations, unlike individual organisms, are exposed to multiple interacting stressors.
- Wildlife population viability is a complex function of habitat quality, fragmentation, connectivity, species' life history, species interactions, interacting stressors, etc.
- The need for technology transfer means that such a model must be usable by others. At minimum, this need for user-friendliness doubles the development effort.
- To have practical value, such a model must be general enough that it can be used with a wide array of species, landscapes, disturbance regimes (including toxins), and so on. This represents a significant technological challenge.
- Models of this caliber are constructed in an iterative manner. They must be applied in a wide variety of studies to ensure that their design is sufficient to address real-world concerns. Each new collaboration leads to design modifications and enhancements, and this process must continue for many years before a truly usable final product can be delivered.
- The time spent testing new model code (in search of bugs) can exceed development time by an order of magnitude. This massive effort is invisible and never appreciated by managers.

As this new pesticide-focused modeling began, I made a point of being quite vocal about the amount of effort that would be required to complete this task. Not surprisingly, this has done nothing to help my case with management over the years. I am frequently accused of doing nothing of value for EPA, and as you can imagine, this can make the work environment stressful. It has also been difficult to fund such a protracted model development effort. Ultimately, funding had to be obtained from multiple sources.

Work on the PATCH model continued for a time, and PATCH was eventually morphed into HexSim. The development of HexSim has been supported by EPA, the Department of Defense (through SERDP), The University of Washington, US National Marine Fisheries, and the Wilburforce Foundation. HexSim has

gained international attention, and I have collaborated extensively with many colleagues at universities, government agencies, and NGOs in order to further the model development process. HexSim is now nearing completion.

There will always be a need for small enhancements, bug fixes, and significantly, additional documentation and tutorials. But the end the HexSim development effort is in sight. At present, we are completing a module designed specifically for plants, plus working on a new suite of tools for aquatic species. Finishing the plant module will be possible over the next month or two. The funding for the addition of aquatic species is almost gone (we had very little to start with) and it isn't clear whether this can be wrapped up before our money runs out. Having an ability to work with plants and fish should greatly expand the range of HexSim applications that interest EPA.

EPA has a need for a model such as HexSim. Pesticides are still impacting wildlife species of concern, and to my knowledge, EFED has no credible methodologies for scaling up from organisms to populations. HexSim is the only tool in existence that can do this well for multiple taxa, environments, and stressors. EPA also regulates the planting of at least some GMO crops. There are now "Round Up ready" crops being planted that also produce multiple strains of BT toxins. EPA mandates that these crops be planted in arrays intermixed among native plant species in hopes of stifling the evolution of BT-resistant insect communities. Apparently, efforts to-date have not been very successful, and there is a clear role for HexSim in designing more mutation-suppressing cropping patterns.

The SHC, and other National Programs, have a focus on sustainability. Wildlife population viability has been a traditional component of sustainability, and HexSim is the best forecasting tool available for anticipating wildlife responses to human activities. Americans consider wildlife an important component of a healthy environment, and for many people, protecting the environment means ensuring the survival of songbirds, waterfowl, and other charismatic species. The EPA Regional Offices have multiple uses for forecasting tools like HexSim, as evidenced in my collaboration with Region 7 involving the prairie chicken (which is a candidate for listing under the ESA). And it is worth pointing out that WED's niche includes being the only terrestrial ecology lab in NHEERL. Wildlife forecasting and population viability analyses are fundamental components of applied terrestrial ecology.

Another example of HexSim's utility to EPA involves linking ecology with human health through the study of zoonotic disease. Wildlife diseases such as plague, rabies, Lime disease, and West Nile virus, are human health concerns, and the geography of emergence and the rate of spread of these diseases can be influenced by human activities. HexSim has the ability to simulate many zoonotic disease systems, and it is well-suited for exploring how diseases might spread through wildlife communities in close proximity to humans developments, and how the resultant risks to people might change in time.

Enormous effort has gone into making HexSim a truly usable research tool that can address some of the complex problems facing our agency. Getting to this point required many external collaborations because interested agency partners have been hard to identify. Contributing to all of these studies took time, but was necessary. Now HexSim is becoming recognized as an vital contribution to wildlife science and conservation, and this value should be appreciated by ORD as well. Applications to programmatic agency needs will directly follow the model development phase. But a complete lack of extramural funding means that agency studies must be performed using existing employees, and it can be hard to find available staff with the necessary skills. This is a problem that management might help solve.